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Division of Dairy Husbandry

Grading Cream For Buttermaking

by
H. A. Bendixen and E. V. Ellington

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GRADING CREAM FOR BUTTERMAKING*

By H. A. Bendixen and E. V. Ellington

Introduction

In the purchase of cream and all other goods, the wise buyer not only considers quantity, but quality as well. Quantity is usually measured without difficulty. Quality determination is often more difficult, but of greater actual importance in establishing true values. It must proceed in the light of the intended use of the article. Thus the value of cream must be judged differently if it is to be used for churning than if it is to serve as whipping cream, coffee cream, or as an ingredient of ice cream.

The value of churning cream obviously depends upon the amount and value of butter that can be made from it together with the amount and value of the resulting by-product, buttermilk, minus the cost of conversion.

Since the perfection of reliable methods for determination of butterfat content of cream and with the availablity of accurate scales for weighing cream, it becomes a simple matter to determine the amount of butter that a certain quantity of cream may be made to produce. Because of the minor value of the by-products from the churning of cream, little attention has been paid in the past to the solids-not-fat content of cream, although more stress should probably be laid upon this quality factor in both cream and milk because of its high nutritive value.

The cost of converting cream into butter may be influenced by the quality of the cream received. Poor quality cream often demands extra handling, and special treatment increases the cost.

The quality of the butter that may be made from cream with the ordinary equipment with average skill and the exercise of reasonable care in handling, however, is of greatest importance in fixing the value of cream for buttermaking. Certain defects which defy remedial measures are at times found in cream during manufacture into butter, and, since butter is sold on grade based principally upon flavor, cream with such defects cannot and should not be paid for at the same rate as cream which is capable of producing premium butter.

Following are a number of reasons why cream grading is desirable:

*Much of the bacteriological work in this study was done or directed by Dr. L. A. Black, formerly dairy bacteriologist at this station.

D. H. Jacobson and R. C. Welch, fellows in the Department of Dairy Husbandry, did much of the actual work in connection with the study of the importance of flavor, acidity, and protein decomposition in the cream respectively. To these men, the writers express their indebtedness.

(1) It is economically sound and ethically fair to pay for cream in accordance with the grade of butter that may be produced from it and with the cost of conversion, which is highest for poor quality cream.

(2) Grading rewards skill and care on the part of the cream producer without imposing serious hardships upon him, and to some extent discourages cream producers who are not dairymen at heart.

(3) It is the most effective inducement for high quality production, which in turn will encourage increased consumption and improve market conditions for the manufacturer.

(4) It stimulates the dealer to increase sales since he is able to depend on a grade of butter of uniform quality.

(5) It gives the consumer the privilege of choosing the grade most adapted to his circumstances and needs, and makes this highly nutritious food more available to him.

Lack of grading results in a generally low quality of butter, in decreased consumption, greater manufacturing and marketing costs, and smaller returns to the producer.

Recognizing the desirability of cream grading, the two greatest obstacles to its success today are the lack of an absolutely accurate as well as practical grading test and the difficulty of enforcing a grading system when adopted.

The study reported here was an attempt to test out the efficiency of existing cream grading systems and to find other grading tests which might successfully indicate the quality of cream for buttermaking.

Flavor and Odor as a Basis of Cream Grading

Most of the cream grading systems that are or have been in practical use in this country consider flavor and odor as an important criterion of cream quality. This criterion is logical since the quality and grade of butter are principally dependent upon flavor as determined by official graders. However, any quality determination based upon the exercise of the human senses, especially those of taste and smell which are commonly most poorly developed in man, are inherently inaccurate and therefore subject to criticism.

The flavors of cream may be derived from a variety of sources, which differ considerably in nature and intensity. Some of them are volatile and exist in a rather loose, perhaps a water soluble, form in the cream. They may be considerably reduced or entirely eliminated during processing. Others, however, remain or may be intensified during handling of the cream and its conversion into butter. Thus a slightly off-flavored cream may not always result in off-flavored butter, and a clean-flavored cream may at times contain the agencies that are capable of developing off-flavors in the butter or of predisposing the butter to early flavor deterioration.

In an experiment involving 31 churnings the cream, consisting of shipments by various farmers, was classified as clean in flavor, slightly off-flavored, and distinctly off-flavored. The flavor was considered independent of acidity, with sourness not being classed as an off-flavor. The sour cream samples were standardized to an acidity of approximately .25 per cent by means of a sodium neutralizer, pasteurized in a coil vat at a temperature of 145° to 148° F. for 30 minutes, and churned, every effort being made to keep the procedure uniform and at the same time insure uniform results. As an aid to maintenance of uniformity, each churning of butter was analyzed for fat, moisture, salt, and curd by the Kohman method. The butter was scored by three judges, a commercial and educational judge of national reputation located in the middle west, a federal-state Pacific Coast judge, and the senior author.

Three 10-pound samples of butter from each churning were taken for analysis and scoring. The sample to be studied locally was immediately placed in cold storage to be scored fresh and after storage of one, three, and six months. The other two samples were chilled in the storage room to prepare them for shipment. They were then taken out, packed in well-insulated boxes, and shipped by express to their respective destinations where they were scored and then placed in cold storage.

During the scoring of the locally stored butter, the boxes were taken out of storage and tempered for 24 hours previous to scoring. This tempering is mentioned as the periodic rise in temperature may have affected the rate of deterioration slightly.

Before presenting the data showing the relationship between cream quality by various tests and butter quality as determined by well qualified butter judges, it seems desirable to point out the divergencies that still exist in our system of scoring butter in spite of the fact that the scoring of this product is perhaps more standardized than the scoring of other dairy products. This lack of uniformity in the judging standards among commercial as well as educational judges constitutes a weakness in butter grading as serious as that found in the grading of cream. It also makes any attempt to correlate cream quality with butter quality a difficult problem. Nevertheless, no more accurate and at the same time practical measuring stick for butter quality is available at this time.

Judges varied as much as five points on the flavor score of identical samples of fresh and storage butter. The greatest disagreement in scores seemed to occur on the butter from the sour cream samples. The fresh butter scores of judge C averaged 1.19 points higher than those of judge A and 1.81 points higher than those of judge B, while the scores of judge C, after six months' storage of the butter, were 0.24 points higher than those of judge A and 0.58 points higher than those

of judge B. The variation in scores was less, therefore, on the storage butter than on the fresh butter.

Since our grading system for butter based upon the judging of flavor is subject to considerable error, it would seem from the start that the grading of cream by the same organoleptic method is in itself insufficient and inaccurate unless great efforts are made to standardize the scoring and to keep it standardized.

Considering the individual and average scores of the judges in the experiment, it seemed that the scores of the butter samples made from clean-flavored cream differed little from those of the butter samples made from slightly off-flavored cream both when fresh and after storage. Distinctly off-flavored cream made butter scoring, on the average, about two points lower for both the fresh and the storage samples. However, according to all three judges, one of the off-flavored samples made butter that scored 35 or above in flavor when fresh, and one of the judges still scored it 35 after six months' storage. Probably the off-flavor in this sample was largely eliminated in processing.

Some slight off-flavors noticed in certain samples of cream evidently did not materially affect the quality of the resulting butter. In most cases, these slight off-flavors were probably caused by feed, but in a few cases they were designated as slightly stale and slightly cheesy. One sample which was pronounced "slightly stale" made butter that scored very low, and should no doubt have been grouped with the off-flavored samples.

Another sample of cream that was classed as clean-flavored made very low scoring butter.

Table 1 shows the scores of the butter made from the three classes of cream on the basis of flavor.

Table 1. Flavor of Cream and Keeping Quality of the Resulting Butter

Flavor of cream	No. of samples	Judge A			Judge B		
		Fresh*	6 Mos.	Loss in score	Fresh	6 Mos.	Loss in score
Clean	15	36.57	34.27	1.30	34.90	33.97	0.93
Slightly off	12	35.25	34.08	1.17	34.79	34.04	0.75
Off	4	32.87	32.62	0.25	32.75	31.25	1.50

Flavor of cream	No. of samples	Judge C			Average of three judges		
		Fresh	6 Mos.	Loss in score	Fresh	6 Mos.	Loss in score
Clean	15	36.23	34.57	1.66	35.57	34.27	1.30
Slightly off	12	36.71	34.12	1.59	35.58	34.08	1.50
Off	4	35.25	33.25	2.00	33.62	32.37	1.25

*The fresh butter scores of judge A are the averages of his scores on the butter when fresh and when one month old, in order to make them comparable with the scores of judges B and C, who scored the butter when two to three weeks old.

It seems, therefore, that other factors besides cream flavor considerably affect the flavor of butter. In the case of the clean-flavored cream some of the samples must have been undesirable in certain respects other than flavor, and in the case of the off-flavored cream some of the off-flavors must have been eliminated in processing or were less noticeable in the butter than in the cream.

Flavor of Cream and Keeping Quality of Butter

Loss in score during storage is sometimes given as a measure of the keeping quality of butter. This loss, however, can hardly be considered a true measure of the keeping quality of the butter because judges are often more discriminative when scoring butter of the higher qualities (above 35) than when scoring the poorer grades (below 35) of butter.

Table I shows that there is no correlation between flavor of cream and loss in score of butter during storage. The comparative scores at the end of the storage period are, therefore, perhaps more significant than the loss in score, as the score after six months' storage was always by far the lowest for the butter from the off-flavored cream. A close relationship between flavor in cream and keeping quality of the resulting butter is not shown and would hardly be expected because of the many flavors which may develop during storage.

Flavor Criticisms on Cream and Butter

The flavor criticisms on the cream were somewhat reflected in the flavor criticisms on the fresh butter. The terminology, of course, differs with various judges. The butter made from sweet clean cream was not pronounced clean by all judges. Clean sour cream made butter that was usually criticized as "old cream," "stale" or "cheesy" by the judges. Butter made from the more pronouncedly off-flavored cream received more severe flavor criticisms, such as unclean, fishy, old, stale. After six months in storage, a similar relationship was still evident.

Acidity as a Criterion of Cream Quality

The effect of cream acidity on the quality of the resulting butter has been studied by a number of investigators. As early as 1890 Patrick (26) and in 1892 Patrick, Leighton, and Bisbee (27) studied the comparative effect of sweet and ripened cream on the keeping quality of butter. In 1909 Rogers and Gray (29) and in 1912 Rogers, Thompson, and Keithley (30) published their well-known studies on the effect of cream acidity on keeping quality of butter. All of these studies brought out the fact that cream acidity hastens butter deterioration, although there is no definite relation between cream acidity and the quality of the fresh butter.

Similar findings have been reported by Larsen, Lund, and Miller (19), Dyer (6), Bouska (2), Mortensen (22), White, Trimble, and Wilson (41), and Hunziker (17), although Mortensen (22) found that with low ripening by means of a starter the flavor score of the butter up to two months of age was higher than when sweet cream without starter was used. When starter was added at the churn without ripening the cream, the butter score, even after nine months in storage, was only slightly lower than when sweet cream was used.

Hunziker (17) points out the fact that the keeping quality of unsalted butter at ordinary cooler temperatures is improved by ripening the cream, and that in the case of both salted and unsalted butter the flavor defect commonly referred to as surface taint may be controlled by acid development in the cream. The development of fishy flavors and metallic flavors has been shown by Rogers (28), Guthrie (13), Cusick (4), Sommer and Smith (34), and Davies (5) to be greatly aided by acidity.

Brown (3) found that cream reasonably clean in flavor having an acidity of 0.5 to 0.6 per cent could not be depended upon to make "first grade" (Canadian standards) butter, and concluded that acidity alone is not suitable as a measuring stick in grading cream.

Acidity can be fairly accurately determined in cream, but alone is generally regarded as an insufficient basis of quality determination in cream for buttermaking. Lactic acid in itself is not objectionable from the standpoint of flavor and wholesomeness, and may even be desirable in these respects. However, it may accelerate certain chemical changes in butter and thus hasten deterioration. In addition to lactic acid, there are always varying quantities of other perhaps less desirable acids present in cream, especially in old cream, and a simple analysis does not reveal these other acids apart from the total acidity. Acidity can also be safely reduced by the proper use of harmless alkalis, and in this way its possible ill effects on the quality of the butter are reduced. Most of the acid in cream is produced by microorganisms, which again may be desirable or undesirable in nature. The undesirable types may seriously affect the flavor of the resulting butter, but the number of these and the proportion in which they are present is not indicated by the acidity determination. The acidity determination alone, therefore, can hardly be expected to indicate the value of cream for buttermaking.

Tables 2 and 3 show the relationship of cream acidity and butter quality brought out in our own studies. The percentage of serum acidity indicates the concentration of lactic acid in the non-fatty portion of cream, and since fat is not dissolved in this portion and, therefore, does not dilute the acid it may be that the percentage of serum acidity more directly affects the quality of cream for churning than the

Table 2. Effect of Acidity of Cream on Keeping Quality of Butter

Acidity of cream	Number of samples	Average score on butter											
		Judge A			Judge B			Judge C			Av. of 3 judges		
		Fresh	6 Mos.	Loss	Fresh	6 Mos.	Loss	Fresh	6 Mos.	Loss	Fresh	6 Mos.	Loss
Below .20	11	36.09	34.68	1.41	35.86	34.59	1.27	37.32	34.58	2.74	36.42	34.62	1.80
.20 — .29	1	35.50	33.00	2.50	35.00	35.00	0.00	37.00	34.00	3.00	35.83	34.00	1.83
.30 — .39	9	34.78	34.28	0.50	34.32	33.44	0.88	35.78	33.55	2.23	34.96	33.76	1.20
.40 — .49	4	34.75	33.12	1.63	33.12	33.12	0.00	35.25	35.00	0.25	34.37	33.75	.62
.50 — .59	4	34.25	33.37	0.88	33.75	32.25	1.50	35.62	34.19	1.43	34.54	33.27	1.27
.60 or above	2	33.25	32.50	0.75	33.50	32.00	1.50	36.00	33.87	2.13	34.25	32.79	1.46

Table 3. Effect of Serum Acidity* of Cream on Keeping Quality of Butter

Serum Acidity of cream	Number of samples	Average score on butter											
		Judge A			Judge B			Judge C			Av. of 3 judges		
		Fresh	6 Mos.	Loss	Fresh	6 Mos.	Loss	Fresh	6 Mos.	Loss	Fresh	6 Mos.	Loss
Below .20	5	36.40	34.40	2.00	36.00	34.70	1.30	37.40	34.60	2.80	36.60	34.57	2.03
.20 — .29	6	35.83	34.75	1.08	35.75	34.67	1.08	37.25	34.58	2.67	36.28	34.67	1.61
.30 — .39	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.40 — .49	3	34.67	33.50	1.17	34.00	34.00	0.00	36.00	34.67	1.33	34.89	34.06	0.83
.50 — .59	6	34.67	34.17	0.50	34.33	33.16	2.84	35.58	32.91	2.67	34.86	33.41	1.45
.60 — .69	4	35.75	34.37	1.38	34.37	34.62	0.25	35.87	35.12	0.75	35.33	34.70	0.63
.70 or above	7	33.71	32.79	0.92	33.14	31.71	1.43	35.64	34.07	1.57	34.16	32.86	1.30
Below .3	11	36.09	34.59	1.50	35.86	34.68	1.18	37.32	34.59	2.73	36.42	34.62	1.80
.3 — .69	13	35.00	34.08	0.92	34.27	33.80	0.47	35.77	34.00	1.77	35.01	33.96	1.05
.7 or above	7	33.71	32.79	0.92	33.14	31.71	1.43	35.64	34.07	1.57	34.16	32.86	1.30

*Per cent serum acidity $= \frac{\text{per cent lactic acid} \times 100}{100 - \text{per cent butterfat}}$

straight percentage of lactic acid. From Table 3 it appears that cream with a serum acidity of less than .3 per cent made definitely the highest average score butter, while cream of a serum acidity of .7 per cent or higher made outstandingly the lowest average score butter. A similar relationship still existed after the butter had been stored for six months.

When considering the individual samples, however, large variations are seen to occur in the relationship between acidity of cream and score of butter, indicating that acidity or serum acidity in cream is by no means the only factor influencing the quality and keeping quality of cream.

Hydrogen Ion Concentration of Cream

The hydrogen ion concentration of cream expressed as pH, being a measure of the intensity of the total acidity present rather than the amount of acid as determined by titration with an alkali, did not offer a better basis for the classification of churning cream than serum acidity. As a matter of fact, the pH values very closely followed the percentage of serum acidity in cream. The pH determinations were made by the colorimetric method with Lamotte color standards, and the cream was diluted with 19 parts of distilled water to facilitate comparison of colors. The pH of the samples ran from 4.9 to 7.0, and cream with a pH of less than 6 produced butter that was scored markedly lower in flavor than cream with a pH of 6 or over. The loss in score of the butter during storage for six months was greatest for the higher scoring samples made from cream of the higher pH. However, butter from the cream with a high pH still scored considerably higher after storage than that made from the cream with a low pH. Spitzer and associates (35) studied the hydrogen ion concentration of the fresh butter and concluded that butter going into storage should have a pH value of not over 5 to 6 to secure the maximum keeping quality.

Other Tests Based Principally Upon Acidity

The curdling test in hot water or coffee has been proposed at times as a useful means of ascertaining quality in cream. This test, however, when compared with the rapid acid determination was found to be less definite, even when it was made more sensitive by the addition of methylene blue dye to the water and a uniform temperature of 200° F. maintained. In general, the curdling test varied quite closely with acidity, but probably is influenced to some extent by the salt balance in the cream.

A colorimetric test, namely the Morres alizarin dye test (24), was studied to determine its usefulness in grading cream. It also followed acidity closely, was less definite than the acid determination and, therefore, seemed to have no special advantages. Table 4 shows the rela-

tion of the above two tests to per cent acid, per cent serum acid, pH value of cream, and to score of butter when fresh.

Table 4. Hot Water Test and Alizarin Test as Related to Acidity in Cream and Butter Scores

Hot water test	Alizarin test	Per cent acidity	Per cent serum acidity	pH	Butter score		Number of samples
					Fresh	6 Mos.	
−	Lavender	.10-.17	.15-.27	7.0-6.5	37.3-35.3	35.7-33.8	11
±	Brown-lavender	.25-.36	.40-.53	6.4-5.7	35.8-34.2	34.3-32.3	3
−	Brown lavender, brown or brown yellow	.34-.50	.49-.75	6.2-5.2	36.3-34.7	35.2-32.7	10
+	Brown, brown yellow or yellow	.46-.78	.70-1.24	5.8-4.8	35.3-32.2	34.2-31.3	7

The alcohol curdling test, which is used to some extent as a quality test for milk, was not found successful in cream. The results were entirely too indefinite.

Present Grading Systems

Acidity and flavor determinations are used together in most of the cream grading systems that are operative today. The grade limits in most cases were set rather arbitrarily or in accordance with general observations and experience. To test out the effectiveness of some of these systems, the following five plans were applied to the 31 samples of cream handled and churned as described before. The California system as applied in this experiment, however, classified all of the cream samples exactly the same as the Alberta system, and the Wyoming plan operated the same as the Washington plan. Consequently, the results were compared only for the Alberta, Washington, and Iowa plans, and it was found that none of these grading systems was absolutely reliable in classifying the cream according to the quality of butter it would produce. The Alberta system appeared to be the most accurate of the three systems studied. The average flavor scores of the butter resulting from the various grades in the three grading systems are shown in Table 5. It will be noticed that when the Washington and Iowa systems are followed to the letter the third grade cream makes as good butter as second grade cream. This result was due to the fact that only cream that is absolutely free from off-flavors is permitted in the "first" grade, while the study seems to indicate that many of the slight off-flavors noticeable in cream have no effect on the flavor of the resulting butter. In actual practice, the slight off-

GRADING SYSTEMS

Grading system	Flavor	Maximum per cent acidity	Minimum per cent fat
Alberta			
Special	Clean, fit for special grade butter	.3	None
First	Reasonably clean, fit for first grade butter	.6	"
Second	Bitter, stale, musty, metallic, or otherwise unclean, but fit for second grade butter	None	"
Off-grade	Very objectionable, such as kerosene, gasoline, stinkweed, onions, or not fit for second-grade butter	"	"
California			
First	Desirable only, fit for 92 or higher score butter	.3	30
Second	Slightly off-flavored, fit for 90-91½ score butter	.6	None
Third	Distinctly off-flavored, fit for 88-89½ score butter	None	"
Washington			
Special	Clean, sweet	.2	"
First	Clean, no off-flavors	.6	"
Second	Moderately off-flavored, foamy, yeasty, metallic, or slightly stale	None	"
Unlawful	Old, moldy, rancid, dirty, etc.	"	"
Wyoming			
Extra	Sweet, no off-flavors	No curdling in hot water, tea or coffee	"
First	Clean	.6	25
Second	Weedy, undesirable	None	None
Illegal	Old, rancid, moldy, filthy, dirty; produced, handled, separated, stored or transported in violation of State Pure Food and Sanitary Laws	"	"
Iowa			
Extra	Sweet, clean	.2	"
First	Clean, no off-flavors	.4	28
Second	Slightly off-flavored	None	None
Illegal	From unhealthy cows, filthy, rancid, decomposed, putrid	"	"

flavors noticed in this study would probably be overlooked by the grader in most cases so that the systems are likely to be more successful in practice than is here indicated. The fault is merely in the wording of the grade specifications, and it is preferable to keep these a little more specific than necessary.

Table 5. Average Scores by Three Judges on Butter Made From Different Grades of Cream

	Number of samples	Flavor scores on butter	
		Fresh	Stored 6 months
Alberta			
Special	4	36.75	34.75
First	22	35.42	34.11
Second	3	34.83	33.14
Off-grade	2	32.67	31.75
Washington			
Special	4	36.75	34.75
First	10	35.22	34.14
Second	15	35.43	33.91
Unlawful	2	32.67	31.75
Iowa			
Extra	4	36.75	34.75
First	5	35.30	34.00
Second	20	35.36	34.00
Illegal	2	32.67	31.75

The Most Effective Grading Plans

On the basis of flavor and acidity the two most effective grading plans, evolved from the data gathered in this study, are the following:

1. Grade—Clean-flavored sweet cream (less than 0.2 per cent acidity or 0.3 per cent serum acidity).
2. Grade—Slightly off-flavored sweet cream, and clean or slightly off-flavored sour cream (any acidity).
3. Grade—Cream showing distinct off-flavors of any kind or slight off-flavors of a very objectionable kind, such as slight cheesiness or staleness and which is either sweet or sour.

The average scores of the three judges for the butter made from these three grades of cream were as follows: 36.7, 35.6, and 33.7 respectively when fresh, and 34.7, 34.3, and 32.5 respectively after storage for six months.

The greatest weakness in this plan is the term "slightly off-flavored,"

which cannot always be properly and uniformly interpreted by all graders. The term "slightly off" as used here refers to an off-flavor which was most likely a mild feed flavor that was largely eliminated during processing. This flavor was, therefore, not highly detrimental. Such flavor defects as "slightly cheesy" and "slightly stale," on the other hand, were very detrimental to the quality of the resulting butter, and cream with such off-flavors, even though they were present to a comparatively slight extent only, should by no means be included in the first grade. Thus grading plans based on flavor and acidity are not perfect and probably never will be. Nevertheless they are the best available at this time.

Methylene Blue Reduction of Cream

The methylene blue reductase test is based upon the assumption that methylene blue dye when added to milk is reduced to a colorless compound at a rate of speed that is very nearly proportional to the number and vigor of the microorganisms growing in it. When applied to milk, the test seems to have considerable value for the estimation of keeping quality. Churning cream quality, however, varies over a much larger range of acidity, age, bacterial count, and other quality indices than milk. For instance, a creamery may receive cream that is absolutely fresh and that has been handled in the most careful manner so that it contains very few microorganisms, and such cream might exhibit weak reducing powers. Another sample of cream might be very high in acidity, old, stale, high in fat and total solids, frozen, or otherwise of a character that would not permit the microorganisms, although present in large numbers, to remain vigorous and active but rather would cause them to become dormant or actually to die off. Such cream would probably be very undesirable for churning, but might reduce methylene blue slowly like very fresh and sweet cream. Thus the methylene blue test would hardly be expected to have any merit as a cream grading test. Experiments at this station bear out this statement. They also showed that proteolytic, alkali-forming, inert, and high lactic acid producing organisms reduce milk and cream as effectively as the ordinary lactic acid bacteria. The reducing power of different organisms and of the same organisms under different conditions also appeared variable. Consequently, neither acid development nor bacterial counts bear any direct relationship to methylene blue reduction.

The normal trend of methylene blue reduction in raw milk and cream held at 40-70° F. was as follows:

In the fresh products reduction time was high. When acidity and bacterial content increased actively, the reduction time was low. As soon as the acid production and cell multiplication showed signs of

slowing up, although they were not at a standstill as yet, reduction time increased slightly. This lag in reduction time, however, seldom persisted very long and usually decreased again without delay, remaining low for many days regardless of further acidity increases or decreases. The lag in reducing power of the milk and cream was probably due to a change in the bacterial flora, namely a decline of the ordinary lactic acid bacteria and a slow gradual increase in other types such as yeasts and molds, proteolytic, and high lactic acid-producing and other groups of organisms. At 98° F. reducing power became negligible in cream after seven to nine days when a high acidity had developed, especially in the samples highest in fat. At this stage, the cream would, of course, be unfit for consumption.

Thus a close relationship between methylene blue reduction time and the quality of cream for churning, as indicated by the scores of the butter made from it, is not to be expected and was not found in the experiments, as shown in Table 6. The nine highest scoring samples of butter were made from cream that required from 15 to 180 minutes for reduction; the three lowest scoring samples originated from cream samples that reduced in 15 to 120 minutes; of the 19 butter samples with intermediate scores, all except three were derived from cream that reduced in 10 minutes or less. The average reduction time of the sweet cream samples was 52 minutes and of the sour cream samples 20 minutes. Within the sweet and sour cream groups, however, there was no correlation between reduction time and the flavor score of butter, either when fresh or after storage.

Bacterial Counts of the Cream

The most common quality test applied to milk is the standard plate count for bacteria. The question then arises of the usefulness of this and other bacterial counts as a grading test for churning cream. That the presence of various types of microorganisms in cream may be injurious to the quality of the resulting butter is certain (16, 31). The results of experiments recorded in Table 6 seem to be negative. The standard plate counts of the raw cream samples on Bacto dehydrated agar appeared to bear no relationship whatever to the scores of the fresh butters made from them. Likewise there seemed to be no correlation between the plate counts of the raw cream and the score of the butter samples after six months' storage. The average count of the sour cream samples was only slightly higher than that of the sweet cream samples.

Table 6. Number and Reducing Power Microorganisms in Raw Cream and Score of Butter

Butter			Raw cream								
			Microorganism counts per cc.								
Score when fresh Av. 3 judges	Score after 6 Mos.	Standard total millions	Nutritive total millions	Caseinate proteolytic millions	Direct count millions	Yeasts and molds	Methylene blue reduction Min.	Flavor	% Serum acidity	% Starter	Sample No.
37.3	35.3	128.0	1,680.0	0	255	1,200	15	Clean	.19	0	20
36.8	34.5	17.3	39.5	2.0	102	730	15	Sl. off	.25	9	21
36.8	35.0	163.0	163.0	0	156	70	30	Sl. off	.24	15	23
36.8	34.7	153.0	204.0	0	936	0	30	Sl. off	.18	0	30
36.7	35.7	210.0	3,750.0	75.0	515	10	30	Sl. off	.26	0	25
36.7	34.3	34.0	158.5	22.0	51	20	180+	Clean	.22	0	17
36.7	34.0	35.6	3.5	.01	25	30	180+	Clean	.15	0	18
36.3	35.3	74.8	115.0	0	204	40	30	Clean	.17	0	19
36.3	35.2	235.0	177.0	0	857	12,000	20	Clean (S)**	.60	0	14
36.2	34.5	7.8	695.0	3.0	877	590	5	Sl. off (S)	.56	18	26
36.0	33.6	330.0	.9	0	1,222	7,000	8	Clean (S)	.75	0	15
35.8	33.8	153.0	204.0	0	936	0	30	Sl. off	.18	22	29
35.8	34.0	675.0	2,999.0	155.0	253	40	10	Sl. off (S)	.40	12*	22
35.5	35.0	185.0	.....	.....	90	1,600	5	Clean (S)	.54	0	8
35.3	33.7	96.0	240.0	.01	404	2,900	120	Off (S)	.91	0	31
35.3	34.3	48.0	16,360.0	4.0	224	40	10	Sl. off	.27	18	28
35.3	34.2	22.0	27,100.0	260.0	122	90	25	Sl. off	.22	0	24
35.3	33.6	168.0	291.0	0	1,031	8,000	4	Clean (S)	.93	0	13
35.2	34.0	2.8	.....	.....	450	120	10	Clean (S)	.63	0	2
35.0	34.8	207.0	.....	.....	204	8,800	10	Clean (S)	.66	0	10
34.8	34.8	10.1	.....	.....	750	4,300	5	Clean (S)	.67	0	9
34.8	33.7	115.0	.....	.....	255	1,150	5	Clean (S)	.56	0	3
34.7	33.8	123.0	.....	.....	96	2,000	3	Clean (S)	.49	0	5
34.7	32.7	66.5	.....	.....	11	460	3	Sl. off (S)	.54	0	6
34.7	34.2	316.0	.....	.....	750	162,000	5	Clean (S)	.88	0	11
34.2	34.3	16.5	.....	.....	75	640	4	Sl. off (S)	.46	0*	4
34.2	32.3	75.0	.....	.....	35	1,360	4	Clean (S)	.53	0	7
33.8	32.3	140.0	12,760.0	35.0	847	30	3	Off (S)	.56	11*	27
33.2	32.0	112.0	164.5	0	653	327,000	40	Off (S)	1.24	0	16
32.5	31.3	35.0	.....	.....	2,958	18,000	15	Sl. off (S)	.70	0	12
32.2	31.5	78.0	6.9	0	472	12,900	120	Off (S)	.93	0	32
			Arithmetic averages for sweet cream samples.								
36.4	34.6	94.0	4,525.0	33	321	203	52		.21		
			Arithmetic averages for sour cream samples.								
34.7	33.5	150.0	1,926.0	21	615	28,544	20		.68		

*Sour cream, not neutralized.
**(S) indicates cream sour to the taste.

The **direct microscopic count** was made on the cream by use of Newman's (23) stain, formula No. 1. Considerable difficulty was experienced in obtaining satisfactory counts as a result of the high fat content of the cream. A long drying period was helpful, but the reliability of the counts in all cases is doubtful. At any rate, Table 6 shows no relation between the direct microscopic counts of the raw cream and the quality and keeping quality of the butter made from it, expressed by the flavor scores of the fresh and stored butter. The count did average considerably higher for sour cream than for sweet cream, but some of the sour cream samples gave low counts and some of the sweet cream samples high counts.

The Yeast and Mold Count

Because yeasts and molds are destroyed by proper pasteurization, the number of these organisms present in butter is frequently regarded as a fair indication of the efficiency of cream pasteurization and the sanitary methods employed during the manufacture of the butter after pasteurization (14, 25, 36). Hood (15) even recommended the consideration of yeast and mold count as a part of the score card for butter. Macy and Richie (2) concluded that the action of yeasts and molds in butter has no direct influence on the deterioration of butter, although there is no doubt an indirect effect. This was also noted by Shutt (33), Parfitt (25), and Thomason (37). Because efficient pasteurization can be depended upon to destroy the organisms, the relationship between yeast and mold counts in the raw cream to the quality of the butter becomes somewhat more remote.

Yeast and mold counts made on Bacto malt agar plates incubated at room temperature for at least five days averaged lowest for the cream samples making the highest scoring butter, as seen in Table 6. However, the organisms generally grow most profusely in high acid media, and it will be noticed that the average count was 28,544 for the sour cream samples and only 203 for the sweet cream samples. Within the sweet and sour cream samples, the count did not correlate with butter quality or keeping quality. Thus the acidity of the raw cream most likely determined to a large extent both the yeast and mold count and butter quality. The yeast and mold counts were made on dehydrated Bacto malt agar incubated at room temperature for at least five days.

Proteolytic Organisms

Comparatively few microorganisms are able to attack butterfat, the principal ingredient of cream. Lactose decomposition, resulting in the production of lactic acid in cream, has already been discussed with relation to its bearing on butter quality. It remains now to study the effect of protein decomposition in cream on the score of the butter. Investigators do not entirely agree on the relationship that exists between butter deterioration and protein decomposition in cream and

butter. Ferris (8) found that cream graded by commercial graders as inferior for churning purposes contained increased amounts of decomposition products. Spitzer and associates (35) concluded that the quality of butter stored at temperatures above 32° F. decreased as protein hydrolysis increased, and in exhibition butter held at regular storage temperatures they also found a close correlation between the activity of proteolytic bacteria in the butter and loss of score. When examining the individual samples of the exhibition butter, however, there seems to be a by no means direct relation between either the loss in score or the score after storage and the increase in nitrogen not precipitated by phosphotungstic acid and the nitrogen as peptones. Grimes (12) reported that the growth of proteolytic bacteria or their products did not affect the keeping quality in storage at -6° F. of butter made from ripened cream, even though direct inoculations were made, but it must be remembered that proteolytic bacteria are greatly inhibited in their action by the presence of lactic acid organisms. Ferris (7) did not obtain appreciable increases of protein decomposition products in butter by inoculating raw and pasteurized cream with pure cultures of proteolytic organisms, although extended incubation of the inoculated cream resulted in low scoring butter.

The proteolytic counts shown in Table 6 were made on dehydrated Bacto nutritive caseinate agar. This count, however, was not found satisfactory on sour cream because, with the high dilutions necessary in plating the sour cream, the proteolytic colonies frequently did not appear on the plates while with lower dilutions the plates would be so thickly seeded with acid-forming organisms as to vitiate the proteolytic count. The counts obtained bore no relation to the quality and keeping quality of the butter.

Table 7 shows the total and also the proteolytic counts on the nutritive caseinate agar of Ayers and Mudge (1) at various stages during the processing and churning of the cream. Nowhere could a correlation be found between these counts and the scores of the fresh and stored butter. Frequently sour cream and sour cream butter ran lower in proteolytic counts than sweet cream and sweet cream butter, on account of the fact that the proteolytic organisms were prevented from developing on the plates by excessive numbers of lactic acid bacteria. This fact is brought out rather interestingly in the results on 22 other churnings shown in Table 8 where the logarithmic average of the proteolytic counts on 12 samples of fresh sweet cream butter was 700 and on the 10 samples of fresh sour cream butter 306 and percentage of proteolytic bacteria of total count was 12.9 and 8.6 per cent respectively. After three months in storage the lactic acid bacteria no doubt decreased greatly in number. Consequently the proteolytic organisms constituted a higher percentage of the total count in the sour cream, and the proteolytic count, therefore, appeared higher.

Table 7. Nutritive Caseinate Agar Counts on Cream and Butter and Scores of Fresh Butter

Score of fresh butter. Av. 3 judges	Total caseinate agar counts Before churning: Raw cream millions	After past. thousands	Thousands	Starter added thousands	Buttermilk thousands	Butter thousands	Proteolytic organism count Before churning: Raw cream millions	After past. thousands	thousands	Starter added thousands	Buttermilk thousands	Butter thousands	Raw cream: Percent starter	Per cent serum solids	Sample No.
37.3	1,680.0	140.0	66.0	.....	685	23	0.0	0.0	8.0	....	14.0	1.3	0	.19	20
36.8	39.5	16.0	13.0	69,000	175,000	5,380	2.0	0.0	0.5	0.0	0.0	15.0	9	.25	21
36.8	163.0	5.0	1.1	755,000	1,240,000	3,250	0.0	1.8	0.1	0.0	0.0	0.0	15	.24	23
36.8	204.0	4.3	3.7	.....	17	2	0.0	4.0	0.3	....	0.0	0.0	0	.18	30
36.7	3,750.0	15.5	6.7	.....	10	6	75.0	4.5	0.7	....	0.2	0.0	0	.26	25
36.7	158.5	3.2	3.6	.....	95	1	22.0	0.0	0.1	....	9.5	0.5	0	.22	17
36.7	3.5	.2	15.3	.....	24	2	0.01	0.0	0.0	....	0.0	0.0	0	.15	18
36.3	115.0	.2	170.0	.....	1,295	97	0.0	0.0	10.0	....	195.0	25.5	0	.17	19
36.3	177.0	4.5	580.0	.....	1,815	106	0.0	0.0	50.0	....	205.0	19.0	0	.60 (S)†	14
36.2	695.0	74.0	248.0	180,000	91,000	11	3.0	0.2	4.5	0.0	2.0	6.0	18	.56 (S)	26
36.0	*9	3.5	75.0	.....	162	34	0.0	1.5	0.3	....	35.0	31.0	0	.75 (S)	15
35.8	204.0	4.3	3.7	700	29	5	0.0	4.0	0.3	0.2	2.0	0.3	22	.18	29
35.8	2,999.0	660.0	1,025.0	2,425,000	1,490,000	440	155.0	3.0	20.0	?	?	0.3	12*	.40 (S)	22
35.3	240.0	128.0	83.0	.....	125	3	0.01	0.2	0.1	....	8.0	0.0	0	.91 (S)	31
35.3	10,360.0	345.0	24.0	32,000	12	0.3	4.0	0.0	0.0	0.0	0.9	0.0	18	.21	28
35.3	27,100.0	8,525.0	115.0	.....	1,370	179	260.0	many	43.5	...	500.0	1.0	0	.22	24
35.3	291.0	41.5	222.0	.....	375	17	0.0	0.0	0.0	....	0.0	0.0	0	.93 (S)	13
33.8	12,760.0	17.0	83.0	.....	2,500	76	35.0	0.2	0.0	....	0.0	0.0	11*	1.24 (S)	27
33.2	164.5	4.8	18.2	7,000	505	12	0.0	0.1	5.2	0.0	205.0	3.8	0	.70 (S)	16
32.2	6.9	14.0	43.0	.....	44	5	0.0	0.0	0.2	....	3.0	0.2	0	.93 (S)	32

*Sour cream, not neutralized.
† (S) indicates cream sour to the taste.

In the sweet cream butter, the reverse happened, because here the acid-forming organisms seemed to remain more active because of the lower acidity and the proteolytic bacteria decreased. Table 8 brings out no correlation between proteolytic organisms in the butter and its flavor score. The 12 samples of sweet cream butter were made from cream containing from .11 to .14 per cent lactic acid, and the 10 samples of sour cream butter from cream of .5 to .6 per cent acidity.

Since proteolytic organisms no doubt vary much in their proteolytic powers, a better correlation might possibly exist between the amounts of decomposition protein material in cream and butter and the quality of the butter. Consequently, the same 22 churnings of cream whose butter scores were recorded in Table 8 were examined for the extent of their protein decomposition. For this purpose, modifications of the Sorensen titration (10), the Foreman titration (9, 21), and the micro modification of the Van Slyke determination of aliphatic amino groups were used (18, 32, 38, 39, 40). The exact range and nature of the pro-

Table 8. Score and Proteolytic Bacteria of Butter
(Averages of counts are logarithmic averages)

Sample No.	Butter score		Proteolytic plate count in butter					
			Number per cc.			Per cent of total count		
	Fresh	Loss 0-6 Mos.	Fresh	3 Mos.	6 Mos.	Fresh	3 Mos.	6 Mos.
			Sweet Cream Butter					
15	38.0	1.5	00	00	100	00.0	00.0	6.66
1	38.0	2.0	Lost	20	30	Lost	36.3	10.70
14	38.0	3.0	1700	00	100	9.6	.0	14.20
5	38.0	3.0	4000	50	900	40.4	18.5	11.30
11	37.5	1.0	300	100	00	30.4	15.3	.00
3	37.5	1.0	12000	250	2700	48.0	6.4	20.80
6	37.5	2.0	2300	100	900	22.5	4.9	20.50
13	37.5	2.0	300	150	100	23.1	9.1	33.30
8	37.0	1.0	1600	100	300	17.0	5.0	31.50
7	37.0	1.0	3500	50	500	27.6	27.8	18.50
2	36.5	1.0	Lost	60	200	Lost	19.4	4.10
10	36.0	0.0	330	20	100	50.8	4.3	20.00
Av.	37.4	1.6	700	34	151	12.9	3.6	11.80
			Sour Cream Butter					
4	38.0	4.0	3000	800	600	37.5	21.1	8.50
21	36.5	2.0	500	350	100	9.6	10.9	2.20
22	36.0	3.0	9000	550	400	15.5	10.6	9.10
9	35.5	2.0	00	100	100	.0	5.7	5.30
18	35.5	3.0	500	500	300	27.8	12.2	18.20
19	34.5	1.5	500	400	100	14.3	9.1	5.60
20	34.0	0.0	800	350	200	16.7	8.1	8.30
17	34.0	1.5	90	850	100	15.0	15.2	33.30
16	34.0	3.0	150	600	200	8.82	24.0	14.28
12	33.5	1.5	200	550	100	9.52	13.1	9.10
Av.	35.1	2.1	306	445	176	8.60	12.0	8.9

tein derivatives embraced in the results of these determinations is not well understood and varies for each of the three determinations. Nevertheless, the data should be comparable.

However, no definite correlation could be found between the amounts of protein derivatives found in the raw cream and in the butter on the one hand and in the quality and keeping quality of the butter on the other. The values usually were highest in the sour cream and the sour cream butter than in the sweet cream and sweet cream butter. They also usually increased in the butter during storage, but seem to have no practical value in grading cream for buttermaking.

Conclusions on Cream Grading

To date no absolutely reliable grading system has been brought forth because of the complexity of the factors that influence flavor in butter and cream. The problem of quantitatively measuring the desirability of a flavor is a perplexing one, and the obstacles to its solution seem unsurmountable when the variety of personal preferences and the inaccuracy of the generally poorly developed human senses of taste and smell are considered. Furthermore, certain off-flavors in the cream will disappear during processing and are therefore of little importance while others persist and greatly affect the score of the butter. Practical experience and the judgment of graders carefully and uniformly trained in the exercise of their senses of taste and smell must still be relied upon therefore in the grading of churning cream.

The consumer who is the ultimate and deciding judge of all goods is generally not extremely discriminative in matters of taste and smell. Nevertheless some consumers are more discriminative than others, and for that reason reasonably accurate standards should be established in judging butter and cream for flavor. These standards must be uniform from coast to coast to make possible the intelligent interpretation of price quotations on grade and to make the trading in butter safe at any distance. Furthermore, the standards should remain fixed under all conditions, and prices rather than grade standards should fluctuate with changes in supply and demand. No grading system for butter can remain standardized and reach its maximum usefulness if, with an oversupply of butter on the market, grade standards rather than prices, are lowered.

Until our judging standards for butter are made uniform and until they remain fixed in spite of fluctuations in supply and demand on the market, any efforts to develop an accurate and fair cream grading system will be seriously handicapped. Although any organoleptic grading plan is inherently inexact, it would no doubt be possible by constant effort to set up fairly uniform grades. This end could probably best be accomplished by a single federal and official coordinating

agency responsible for all official grading of cream and butter, which would set all grading standards and employ coordinating graders who would constantly check on the work of all other graders and who would serve as teachers and trainers for all prospective graders.

A combination of flavor and acidity determination still remains the most dependable means of grading cream. A slight off-flavor in cream, depending of course upon its nature, has often a less pronounced effect on the score of the resulting butter than a slightly perceptible acidity. Distinct off-flavors in the cream, however, markedly lower the score of butter, as does also a serum acidity below .3 per cent in the raw cream.

The cream grading system recommended on the basis of this study is as follows:

Special grade—Clean flavored, sweet cream with less than .2 per cent acidity or .3 per cent serum acidity. (An age limit of two to three days might offer additional security and ease of enforcement.)

First grade—Slightly off-flavored sweet cream, and clean or mildly off-flavored sour cream of an acidity not to exceed .6 per cent. (This acidity limit may be of no importance except that it might cover up certain serious off-flavors.)

Second grade—Cream of any acidity showing distinct off-flavors of any kind or slight off-flavors of a very objectionable kind, such as chessiness or staleness, and which is either sweet or sour.

Unlawful and rejected—Cream produced and handled in violation of state and federal pure food and sanitary laws or which is very objectionable in flavor for churning purposes.

Determination of pH values, the hot water curdling test, the alcohol test, the alizarin dye test, methylene blue reduction time, standard plate counts for bacteria, direct microscopic counts, yeast and mold counts, proteolytic counts, as well as three methods of estimating the state of protein decomposition in cream do not seem to offer sufficient additional help in the grading of cream to warrant their inclusion in the regular grading procedure. Some of them, of course, have value as occasional supplementary tests and determinations.

CREAM GRADING TECHNIQUE

Prerequisite to successful cream grading are sanitary methods of grading and spotless surroundings. The psychological effect of a grader, unclean and slovenly in his appearance, careless in his methods and working in unsanitary surroundings, is not inducive to successful cream grading. The grader, the plant, and its surroundings all should reflect a spirit of painstaking cleanliness, preciseness, and care in every respect. Only clean, dry, sterile cans should ever be returned to the producer. Such a creamery shames, humiliates, convinces, and reforms

the careless cream producer without constant struggles and arguments.

Flavor Determination

The odor of cream should be noticed immediately upon removal of the can cover when it is most pronounced. The cream is thoroughly stirred with a stirring rod. In the case of very rich cream, the hand of the grader should not be used to scrape the cream from the stirrer. Rather a slide attached to the stirring rod or a slit rubber wiper should be used. The hands of the grader should never come in contact with the cream. The cream should not be tasted from a finger inserted into the can, but from a tin spoon or a glass tube or rod. Running water, preferably warm, should be handy to the grader at all times to prevent a messy appearance of the grading floor. Where the overflow from the ammonia condensers in the plant is wasted, it might profitably be made available on the grading floor. A special spittoon, as suggested by Hunziker (16), for the use of the cream grader is excellent and can be made without much expense. Any convenient provision for rinsing the sampling tool of the grader with warm water and for spitting without creating an unsightly and unsanitary appearance of the grading floor would be satisfactory.

It is impossible to define and trace all of the various flavors which might be found in cream. Too often cream contains a mixture of different flavors caused by a variety of conditions, and in such cases it would be very difficult for a grader to detect and identify each individual flavor. Consequently, it will often be necessary for a grader to grade down a sample of cream because of general undesirability of flavor without making a very definite criticism to the producer. This necessity is unfortunate but entirely justifiable.

Whenever possible, of course, graders should try to establish the nature of the off-flavor found in the cream in order to assist the producer in locating the source of the off-flavor and in removing it from future shipments.

Off-flavors may be classed according to their source as follows:

1. Those due to abnormal composition
2. Those due to absorption either before or after the secretion of the milk
3. Those due to the introduction of foreign matter
4. Those due to chemical action
5. Those due to bacteriological action

Off-flavors belonging to the first group will be comparatively rare. They may be described as bitter, salty, or pungent when caused by abnormalities in the milk of cows late or very early in the lactation period or in the milk of sick cows.

Flavors of the second group may be absorbed by the milk within the

body of the cow from strong flavored feeds consumed by the cow and medicines administered to her. After secretion, they may be absorbed from the surrounding atmosphere as barn odors, cellar odors, gasoline odors, etc.

Foreign matter accidentally or intentionally introduced into the milk or cream such as manure, rust from cans, oil, gasoline, chlorine, or alkalis may cause serious off-flavors. Such flavors are absolutely preventable.

Flavors caused by chemical action are rancidity and tallowiness which may be caused by hydrolysis and oxidation of the fat through heat, air, direct sunlight, and other factors. The presence of metallic salts originating from rusty, untinned utensils and equipment will accelerate the appearance of these flavor defects.

Finally, microorganisms are able to produce cheesy, bitter, fishy, yeasty, and other flavors. These off-flavors can always be reduced and retarded in their development by proper care to prevent contamination with the responsible microorganisms and by prompt cooling to prevent their multiplication.

The intensity as well as the nature of the off-flavor must be considered by the grader in each case. Consequently, it is not possible automatically to assign cream containing a flavor of any of the types described above to any definite grade in the grading system, and human judgment must thus enter into the grading to a considerable extent.

Acid Determination

After the cream has been judged on flavor and dumped into the weigh can and has been sampled for fat, the acidity of those samples on the border line for the different grades may be quickly determined by using two dippers of equal size and a standard alkali solution containing phenolphthalein. The alkali solution may be made up for use with any acidity standard as follows:

Take 100 cc. of tenth normal alkali as used in the regular acid determination and add a sufficient amount of distilled water and phenolphthalein to make a total volume equal to $\frac{90}{\%\text{ acid set as grade limit}}$

For instance, if .2 per cent acid is the limit set for special cream, it would be expedient to prepare 90/2 or 450 cc. of alkali solution by taking 100 cc. of N/10 NaOH and adding 350 cc. distilled water and phenolphthalein indicator. Just enough indicator should be used to produce a wine red color in the solution.

The solution together with a metal dipper of approximately 10 cc. capacity is placed in a convenient location for use by the grader. A dipper of exactly the same size is hung to the side of the weigh can.

If when added to and mixed with a dipperful of cream in a white cup a dipperful of the alkali solution does not turn the cream a faint pink, the lactic acid content is in excess of .2 per cent, and if two dipperfuls of the solution do not turn the cream pink the acidity exceeds .4 per cent, etc.

If in the case of a very rich cream an excessive amount of cream clings to the outside of the dipper, this excess should be wiped off with a towel and the inside of the dipper rinsed with warm distilled water which is also added to the cup. The red alkali solution will fade with age and should be made fresh each day in the needed amounts. The test is rapid and sufficiently accurate for practical work. The tenth normal alkali used must, of course, be watched for strength by frequently checking it against tenth normal hydrochloric acid. Instead of using a tenth normal alkali solution as described above, Farrington alkali tablets may be used. If the acidity limit is .2 per cent, two alkali tablets are dissolved in an ounce (30 cc.) of distilled water; if it is .3 per cent, three tablets are used per ounce, etc. No phenolphthalein needs to be added as the indicator is present in the alkali tablet. Chipped tablets, of course, should not be used. In case of a dispute, the regular alkali titration should be applied to determine the exact percentage of lactic acid present.

Age

Without a doubt, age is a very important factor in the quality of churning cream. Nevertheless, seriousness of the effects of age varies with the extent of the initial contamination and the conditions of temperature and surroundings under which the cream is held. Grading on the basis of age alone as on flavor or acidity alone will accomplish some good results. A more complete grading system as recommended even though not perfect is, however, more effective, most just, and less inducive to controversies. Low age is a desirable adjunct to the requirements for Special grade cream. This age limit might be varied during summer and winter months at the discretion of the plant manager. It may also vary in different localities according to the conditions of roads, distance from the plant, and system of delivery, but should seldom exceed two days for the summer months and three days for the winter season, because even at low temperatures cream deteriorates in quality.

The age of the cream may be checked by a system of tagging the producers' cans, as is done in the four-day delivery plan practiced in some of the Middle West states described by Gregory (11). In this system, when a producer delivers a can of cream a small tag is fastened to the can, having stamped on it the date of delivery, the name of the producer, and the name of the creamery. If the next delivery occurs within four days, the producer is entitled to a premium. The reserva-

tion, however, is made in the four-day plan that the cream must not contain any objectionable flavors or odors. If a producer is the regular patron of a creamery, the tagging is unnecessary as the delivery record of the producer at the creamery and the receipt of the producer will indicate the time between deliveries. In a three-grade system, four days would generally be too great an age for cream to be graded as Special. In centralizer territory with a two-grade system, a four-day grading plan evidently has merit, while in an intensified dairy section where high quality is continuously stressed, most cream will in a comparatively short time grade Special and First grade and very little Second grade cream will be received, providing, of course, that a price incentive is provided in the form of a premium for Special grade cream and a deduction for Second grade.

Price Differentials

The price differential is the keystone of success in any grading plan because, without this incentive, extra effort would be provoked and maintained with difficulty. A small price differential, on the other hand, provides a surprisingly strong inducement with the average producer.

The question arises whether cream grading with a price differential is practical and justifiable in the small plant where all cream is mixed together and only one grade of butter is made because not enough cream is received to permit the churning of each grade of cream separately. Cream grading is just as fair and just as necessary, if not more so, in these small plants as in the large plants, since the high quality cream will raise the average score of the butter produced and low grade cream will markedly reduce it. The fairness to the producer is just as apparent, and the encouragement of high quality is just as desirable and perhaps more necessary in the case of the small plant than in that of the large plant. As a matter of fact, high quality is of paramount importance to the success of the small plant today.

The matter of enforcing adapted grading plans is not dealt with here. Obviously strict enforcement is necessary for their smooth and most effective operation. It is believed, however, that the many advantages of cream grading are creating a more and more sympathetic attitude toward the practice among both creamery operators and producers, and consequently less and less coercion becomes necessary in the enforcement of fair and reasonable cream grading procedures.

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